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An Assessment of Climate Change Mitigation via Location-Specific Climate Smart Horticulture: A Review Paper

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ABSTRACT- The first stage in preparing the horticulture industry for creating adaptation plans under climate change scenarios is to quantify the effects of temperature fluctuations, surplus and restricted moisture conditions. Individual crop effects have been studied and assessed throughout the main agro-ecological areas and growing seasons. Scientific validation is required for production methods that may be modified to adapt for climate change. Although production regions for particular crops or the time of sowing and planting may be altered the markets windows as well as infrastructure, like the availability of local packaging as well as the distribution facilities, are important components to consider for many horticultural commodities. It's expected to change key interactions among horticultural plants as well as pollinators, insects, disease, pests, weeds, pests as well as weeds. Because horticulture-based agricultural systems offer a great potential for sequestering carbon for climate change mitigation, there is a need for a fast and clear knowledge of the effect of climate change on horticultural crops in order to develop a solid action plan. Perennial tree work as carbon sinks by sequestering carbon from the atmosphere. The clean development method may be used to get the carbon credits. Based on location-specific climate smart horticulture concepts, an integrated strategy with all available choices will be most successful in maintaining production under climate change circumstances.

KEYWORDS- Climate change, Horticultural crops, Location specific research, Smart Horticulture.

I. INTRODUCTION

Horticulture has advanced rapidly in recent decades, with the effect of new technology like as cultivars and production system management evident in improved output and productivity, which rose more than eleven-fold to 293 million tonnes in 2016-17 from 25 million tonnes in 1950-51 [1]. Certainly, despite numerous difficulties and limitations, the horticulture industry has progressed considerably, and it is now in a critical stage of growth that need efforts for long-term development. Moving weather patterns have made agricultural production more difficult to manage, resulting in increased rainfall unpredictability and extreme high and low temperature regimes, among other things. As a result, it is presenting significant difficulties to agriculture's performance, including both annual and perennial horticultural crops. Rainfed agriculture, on the other hand, would be primarily affected in this scenario owing to rainfall unpredictability and fewer wet days each season [2]. Climate change has increased uncertainties and hazards, placing additional limitations on horticulture production systems.

Short growing periods will have a detrimental effect on growth and development as a consequence of terminal heat stress and reduced water availability, resulting in low yield in fruit and vegetable production. Crop yields may improve as a consequence of a modest rise in temperature at high latitudes, while in tropical areas, even mild warming may result in disproportionate yield reductions. As a consequence, in the event of poor yields, climate change may lead to an increase in the price of fruits and vegetables. However, the difficulties ahead include ensuring long-term viability and competitiveness, as well as achieving targeted production to meet rising demand. Climate change's difficulties and effects, such as changing seasonal patterns, heavy rain, floods, hailstorms, frost, high temperatures, and drought, all contribute to extremes in horticultural output [3]. Shortening of growth seasons, decreased water availability, and inadequate vernalization may all cause yield reduction. As a result, climate-smart horticulture treatments, which are extremely location-specific and knowledge-intensive, are becoming more important for boosting output in the challenging environment.

A. Environmental Physiology

Environmental physiology is also important for studying the effects of various environmental stresses on growth and development, such as shading, heavy metals, drought, and salinity, as well as how plants compensate for the negative effects of stress through various mechanisms such as stress response, acclimation, and adaptation [4]. Knowledge of the relationships between environmental variables and plant physiology aids in the detection of environmental changes such as a lack of light, excessive temperatures, or a lack of water. Shading horticultural crops, for example, may decrease photosynthetic rate, transpiration, stomatal density and conductance, as well as increase flower abortion. High temperatures may also impact pollen viability and germination, as well as the quantity of flowers and fruits per plant. Finally, ecophysiological data may be utilized in breeding programs to develop better cultivars, as well as in agricultural zoning techniques to increase production.

B. Vermitechnology and Climatic Adaptation

Biodegradable waste is generated by horticultural crop leftovers. Waste isn't just waste, even if it's labeled as such. They are unused resources that may be effectively used using basic technologies like vermitechnology [5]. In order of desirability, the waste management method consists of three Rs: Reduce, Reuse, and Recycle. Vermitechnology is a waste management solution that is both eco-friendly and biological. It's a technique of using earthworms to turn trash into compost. Vermicomposting, among other options, has been proposed as a means of converting wastes into beneficial components for plants and soil while reducing negative environmental input. Organic manure containing necessary amino acids raises leaf chlorophyll levels, which boosts metabolite production and increases crop yield. Earthworms need at least two to three weeks to accept horticultural crop waste as substrate and food. Earthworms eat biomass and excrete it as worm castings, which are digested waste. Worm castings are sometimes known as black gold. The casts are high in nutrients, growth-promoting compounds, helpful soil microflora, and pathogenic microbe-inhibiting characteristics. In its peat-like consistency, vermicompost has high porosity and aeration, as well as excellent drainage, aeration, and moisture retention. Humic acid is found in considerable quantities in vermicompost. The slow release of plant nutrients, the enhancement of soil physical qualities, and the augmentation of plant micronutrients via chelation and reactions are just a few of the many important aspects of this product. Vermicompost is gaining traction as a key component of organic farming systems for seedling development and crop production.

II. DISCUSSION

A. Climate Variation As well as Agricultural Production In Relation To Region And Crop

Cashew trees require a relatively dryer as well as mild winter, with a minimum temperature of 15-20°C [6]. However, a lack of rain, poor spreading of rains, increased temperatures, as well as violent winds have been reported to decrease cashew tree output due to abortions or drying of the flowers, falling of the leaves, and immature fruits, and in extreme cases, unproductiveness. From January through May, cashew is subjected to significant moisture stress, which has a negative impact on blooming and fruit set. Cashew is susceptible to climatic fluctuation and drought conditions induced by changes in rainfall patterns and inter-seasonal variability, since it is primarily cultivated under rainfed circumstances. Not only would rising temperatures accelerate nitrogen mineralization in soils and reduce fertilizer effectiveness, but it will also have an impact on insect population survival and dispersion.

Droughts and cyclones, such as those that occurred in Tamil Nadu and Karnataka, and cyclones that occurred in Andhra Pradesh, have had a detrimental impact on coconut crop yields, which have been linked to climate change [7]. There is evidence that carbon stores in shaded agroforestry systems with perennial crops such as coffee, rubber, and cocoa may vary from twelvw to 228.00 Mg ha-1, indicating that they might contribute to climate change mitigation efforts. Many scientists have conducted extensive research on the impact of climate change on medicinal and aromatic plants. Researchers observed that there were considerable fluctuations in climatic conditions that had a major impact on the yield of spice crops such as small cardamom, seed spices, and black pepper throughout the investigation. Due to the effects of climate change, Indian pepper output has been significantly decreasing over the last ten years. The diagnosis and management of soil fertility limitations in coconut may be addressed and have been evaluated, as well as the proper use of genetic resources in cocoa breeding programs for stress tolerance. An experimental arrangement for a confectionery is shown in Table 1.

Table 1: Illustrates experimental layout for a confectionery [8]

Variables/Parameters	Levels	Descriptions	Measuring Parameters
Sample size	1	750 gm	(a) Physico-chemical quality- Moisture content, TSS, Acidity, optical density, Vitamin-C, (b) Sensory quality attributes- (Colour, Taste, Flavour and Texture and Overall acceptability)
TSS (initial)	1	50 °Brix	
TSS (final)	1	75 °Brix	
Citric acid	3	0.5%, 0.75%, 1.0% (w/w)	
Yellow Colour (edible)	1	4 ml	
Preservative (benzoic acid)	1	600 ppm	
Packaging materials	3	Glass Jar, PET Jar and PP pouches	
Replications	3	-	

Mango has a vegetative bias that becomes greater as the temperature rises, affecting blooming phenology. For climate change monitoring, the Biologische Bundesanstalt Bundessortenamt as well as Chemische Industrie (BBCH) scale for phonological study in mango has been modified from its original use in phonological research [9]. The percentage of hermaphrodite flowers in late-emerging panicles was greater, which correlated to higher temperatures. Early or delayed blooming, numerous reproductive flushes, differences in fruit maturity, aberrant fruit set, and the transition of reproductive buds into vegetative buds are all documented effects of climate change on mango. In addition, the transition of reproductive buds into vegetative buds has been documented. Because of the hot and humid conditions, there has been a considerable increase in the number of pests and diseases in guava. Fruit fly in guava is becoming a severe issue as a result of the hot and humid conditions.

Crops that need low chilling temperatures, such as peach and plum, are also exhibiting signs of declining production. Sunburn and cracking in apples, apricots, and cherries are further exacerbated by high temperatures and moisture stress. Increased warmth during fruit maturity causes fruit cracking and burning in litchi, as well as early mango ripening. Temperature has a significant impact on the pace of fruit development, therefore using bunch coverings to warm the fruit improved the rate of growth. Higher temperatures accelerate the pace of plant maturity in bananas, reducing the time it takes for the bunch to grow. Changes in the availability of growing degree-days/temperature under climate change circumstances will accelerate the phenological processes. It was also claimed that European types are more temperature resistant than American cultivars, and that they have the ability to produce wines in hotter climates. In the case of grapevines, bananas, mangoes, and other key horticultural crops, a change in varietal selection may be required. During blooming, water stress produces inadequate finger filling and unmarketable bunches. Water stress has a negative impact on the bunch weight and other development indicators of the crop. When it comes to almond and apricot trees, moderate winter temperatures followed by high spring temperatures hastened bud burst, exposing buds to frost damage. Sunburn and cracking in apples, apricots, and cherries were exacerbated by high temperatures and moisture stress. Micro-irrigation methods have shown to be a benefit for increasing water efficiency in a variety of horticulture crops.

According to studies, high temperatures cause morphological changes such as etiolated development with smaller compound leaves and leaflets, lowering the LAI and decreasing tuber quantity and size. Limited carbohydrate translocation from the leaves to tuber, reduced nitrate reductase activities as well as carbohydrate cost for the dark respiration all contributed to tuber yield inhibition. As a result, a wide range of potato cultivars must be studied in order to develop heat-tolerant types. Despite the fact that cassava and sweet potato are drought resistant, there is a substantial decrease in tuber production and starch content. When available soil moisture falls below 20%, sweet potato yields drop, and the tuber initiations phase is the most vulnerable owing to its impact on tuber numbers. Through the tuber initiation phase, water stress causes tuber lignification, which slows tuber development. Drought tolerance has been found in 3 sweets potato lands races: IGSP 10, VLS6, as well as IGSP 14. CTCRI has produced a drought-tolerant sweet potato cultivar called “Sree Bhadra.” Seed spice crops have also been tested for drought resistance.

It has been shown that the best daily mean temperature for tomato fruit set is between 21 as well as 24 degrees Celsius. Preanthesis is a more vulnerable stage in the development of tomatoes. High temperatures following pollination have been shown to impair pepper fruit set, indicating that the fertilisation process is sensitive to temperature. Fruit drop has been associated to a variety of reproductive difficulties, including bud drop, abnormal flower growth, poor pollen production, dehiscence and viability, ovule abortion and poor viability, and other reproductive issues. Optimal growing conditions for cauliflower include temperatures ranging from 15 to 25 degrees Celsius, along with high humidity. Even while certain cultivars have been used to temperatures in excess of 30 degrees Celsius, the majority of kinds are vulnerable to higher temperatures, resulting in curd formation being delayed until later in the season. Heat and water stress are predicted to have the largest influence on the quality of horticultural products in the coming years. Temperatures over 40°C reduced the size of onion bulbs, whereas temperatures above 38°C reduced onion production by around 3.5 degrees Celsius. Depending on the degree and stage of the occurrence, high temperatures lowered marketable grade tuber production by 10-20 percent, whereas frost damage reduced tuber output by 10-50 percent. When the temperature rises by one degree Celsius, aphids appear two weeks sooner, and the growing period of the potato seed crop is reduced by the same amount.

The employment of morphological or biochemical mechanisms by plants to respond correctly in order to avoid one or more stresses has been shown. There has been evidence that pollutants such as sulphate dioxide, hydrofluoride, nitrogen oxide, ozone, and acid rain all have a detrimental influence on vegetable production in terms of growth, yield, and quality. It has been shown that many vegetable crops, such as tomato and watermelon, potato and squash, soybean and cantaloupe, beet and peas, carrot and turnip, and other crops, are more sensitive to the effects of air pollution. Daily ozone concentrations over 50 parts per billion have been seen to reduce yields of Brassica oleracea, Lactuca sativa, and Raphanus sativus by up to 50 percent, while yields of vegetable crops have been observed to decrease by 5-15 percent. A number of diseases have been reported to be becoming more severe as a consequence of climate change, including stemgall in coriander, for which the resistant variety ACr1 has been recommended for cultivation, and fusarium wilt in tomato, which has been explored for use in breeding programmes.

B. Climate-Smart Horticulture Depending On The Location:

Climate smart horticulture is a method that involves doing site-specific evaluations to find appropriate production technology and methods for addressing various problems in agricultural and food systems at the same time and in a holistic manner [10], [11]. Concerns about climate change, as well as solutions to the issues that develop as a result of them, need local research, planning, as well as administrative efforts. Regional climate change analyses and understandings are required in relation to both annual and perennial horticulture crops, and these challenges may be addressed via innovation, technology evaluation, and refinement in order to provide effective solutions to the problems.

Modeling techniques for impact assessments for different horticulture crops will be suitable for developing adaptation and mitigation strategies. In India, there is a dearth of effective simulation models for horticulture crops, as well as the creation of such models. The Info

Crop models has been modified for tomato and onion crops, and the model is being verified for various agro-ecological areas. Crop simulation models for horticulture crops such as mango, grape, apple, orange, citrus, litchi, and guava are currently a top research focus in India. Crop-based adaptation strategies must be developed based on the vulnerability of certain crops in an agro-ecological region and the length of the growing season, and they must include all available options to ensure that production is not disrupted. Extreme weather conditions such as high temperatures, frost, and moisture stress scenarios that are both limited and excessive have prompted scientists to develop a variety of remedies in the past. These already available technologies may be integrated and used to alleviate the harmful consequences of climate change and variability. - The development of crop, agro-ecological region, and season-based technologies should be prioritised to reduce the impact of climate change on horticulture production systems while also increasing their resistance to the changing weather conditions. In order to combat climate change, resistant root stocks and cultivars for a variety of stress-tolerant fruit crops have been created and are now being deployed.

The emphasis should be on using the recommended production techniques in order to save water and adapt to hot and dry conditions. Another alternative is to use soil amendments to promote soil fertility and nutrient absorption, as well as to vary fertiliser application to increase nutrient availability. The most important treatments are to provide irrigation during critical phases of crop growth and to conserve soil moisture reserves as much as possible. Plant management strategies such as mulching with crop residue and utilising plastic mulches may help to conserve soil moisture by preventing soil erosion. Planting crops on raised beds may help to alleviate the problem of excessive soil moisture produced by heavy rains in certain situations. Clear plastic rain shelters may be used to cultivate vegetables, decreasing the direct impact on fruit trees and lowering the amount of water that accumulates in the field during the rainy season. Planting vegetables on raised beds during the rainy season will result in higher yields due to improved drainage and less anoxic stress to the root system, according to the USDA. Grafting vegetables onto tolerant rootstocks would provide tolerance to soil-related stresses such as drought, salt, low soil temperature, and floods on the scion cultivars used in the grafting.

III. CONCLUSION

A wide range of cultivars and species may be used to swiftly apply adaptation strategies; however, changing planting dates or seasons, as well as establishing and rearranging orchards, need the consideration of climate change's longer-term implications. In order to develop new varieties of crops that are suitable for a variety of agro-ecological zones and changing climatic conditions, breeding activities need be increased. Because of the physiological and physical differences across varieties (genotypes), they may be grown in a broad range of climates, and cultivars can be selected based on their suitability for different growing locations. When there is a high market demand for a particular cultivar and the appropriate types are not available to adapt to the changing environment of a specific growing area, the use of rootstocks to improve the performance of scion cultivars may be considered. Rootstocks are plants that are grown to produce seeds that are then planted to produce fruit.

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